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COMPARISON OF MECHANICAL PROPERTIES OF DUAL PHASE STEEL FOR DIFFERENT QUENCHING MEDIUMS

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ABSTRACT

The objective of this study is to find out the best suitable quenching medium for quenching which effects most on the mechanical properties of medium carbon steel. Specimens were first heated in the Muffle Furnace at three different temperatures (i.e., 760 ºC, 800 ºC & 840 ºC) for holding time of 2, 4 and 6 minutes and then quenched in different quenching medium of (water, air and oil). Dual phase steel which is developed from medium carbon steel after heating were examined to record toughness and hardness of the specimens. The mechanical properties of medium carbon steel untreated specimen were also recorded to compare with treated samples of medium carbon steel. The Rockwell hardness test and Charpy test is used to determine the mechanical properties such as hardness & Toughness of both treated and untreated samples of medium carbon steel. The result indicates that the specimen hardness and toughness are proportional to amount of martensite and amount of martensite depends on intercritical annealing temperature. The hardness of the quenched materials is higher than the parent material. The hardness of the water quenched materials is higher than the other quenched materials. The water quenched material had more hardness & toughness as compared to oil & air, to suggest in improved mechanical properties.

KEYWORDS: Charpy, Dual Phase Steel, Hardness, Martensite, Quenching, Rockwell Hardness

INTRODUCTION

Steel is essentially an alloy of iron and carbon and other alloying elements. The carbon content of steel is between 0.05% and about 1.2%. The other elements may be controlled by impurities or alloying elements that are introduced to alter the response to heat treatment or to produce some special properties. Plain carbon steel is the one in which the only alloying element is carbon. Carbon being a powerful alloying agent can give a variety of strength and hardness by varying its composition in the steel. Carbon steel can be classified in three categories as low, medium and high carbon steel. The carbon steel with carbon content between 0.3 and 0.6% is termed medium carbon steel. While those with lower and higher are respectively classified as mild and high carbon steel. Hardness and other mechanical properties of plain carbon steels increase with the rise in concentration of carbon dissolved in austenite prior to quenching during hardening heat treatment, which may be due to transformation of austenite into martensite. Therefore, the mechanical strength of medium carbon steel steels can be improved by quenching in appropriate medium. However, the major influencing factors in the choice of the quenching medium are the kind of heat treatment, composition of the steel, the sizes and shapes of the parts. The aim of

this paper is to find out the best suitable quenching medium to improve the mechanical properties of medium carbon steel. In the present study, medium carbon steel samples are heat-treated at different temperature above the austenitic region for three different holding times and quenched in water, palm oil and air in order to investigate the effect of different heating temperature, holding time and quenching regimes on the mechanical properties of the steel. The changes in mechanical behavior as compared with un-quenched samples are explained in terms changes in toughness and hardness after quenching treatments.

MATERIALS AND METHODS

The chemical composition of medium carbon steel samples used for the present work 10 mm thick this investigation is given in Table 1.

Table 1: Chemical Compositions of the Medium Carbon Steel Sample

Element	C	Mn	Si	S	P	Cr	Cu
Wt.%	0.468	1.00	0.342	0.031	0.0330	0.042	0.172

Test Specimen Preparation

Different processing operation required to be done on raw material for the specimen preparation before doing any test on it. The samples are subjected to various tests before and after the heat treatment in order to determine their mechanical properties and compared with parent steel. The specimens were prepared after series of machining operations following the International Test Standard, as shown in figure 1.

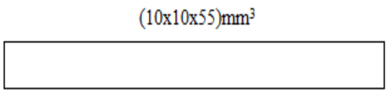


Figure 1

Heat Treatment and Quenching

All the specimens which were already prepared for the various tests were loaded in to a muffle furnace, and samples were heated to 760 ºC, 800 ºC and 840 ºC. They were allowed to get soaked by maintaining them at this temperature for a period of 45 min. The soaked specimens were grouped into three parts. One part was cool in Water. The remaining two parts were quenched in palm oil and air respectively.

Procedural steps for heat treating of work specimen

- Switch ON the furnace and set 760°C temperature in the controller which controls the voltage, current and the temperature inside the furnace.
- Gradually the temperature of the furnace reaches 760°C in 45 min. Temperature will fluctuate between 759°c to 761°C due to error in the thermocouple used so wait for the stable value.
- Now put the work piece on ceramic plate.
- Set timer in the mobile for required time.
- In the end of set time, open the lid of the furnace Remove the material and drop the work piece in the water pool

Use asbestos plate to cover the furnace to avoid heat loss.

- Remove the material, quenched in water, palm oil & cool in air and repeat steps for other sample.

Table 2: Showing Selected Heating Temperature and Holding Time

Specimen	1	2	3	4
Temperature(°C)	0	760	800	840
Holding time(min)	0	2,4,6	2,4,6	2,4,6

Charpy Impact Testing

Charpy impact is practical for the assessment of brittle fracture of metals. An impact test signifies toughness of material that is ability of material to absorb energy during the plastic deformation. The Charpy test sample has (10x10x55) mm^3 dimensions, a 45^0 V notch of 2 mm depth and a 0.25 mm root radius will be hit by a pendulum attach opposite end of the notch as shown in Figure 2**.** As the pendulum is raised to a specific position, the potential energy (mgh) equal to approximately 300J is stored. The potential energy is converted into the kinetic energy after releasing the pendulum.

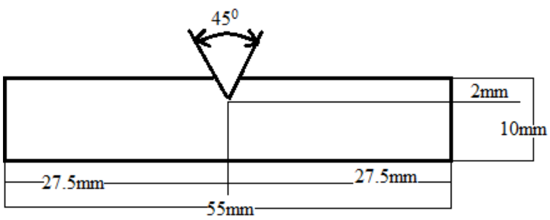


Figure 2: Showing Sample of Charpy Test

Charpy Test Procedure

- Raise the pendulum to position of 135° with the vertical and hold it there with the help of stop device and safety lever should be in the charpy position.
- Mark the loose dial pointer in contact with the pointer fixed with the pendulum.
- Release the pendulum with the help of trigger when there is no specimen in the vice.
- Note down the reading of pendulum by the position of loose dial pointer, this reading is E1.
- Bring the pendulum to static position and raise it again to position of 135° and Holt it there by stop device.
- Place test piece in the vice in simply supported position.
- Release the pendulum with the help of trigger.
- It will strike at specimen with the speed of 3-4m/s.
- Note down the reading of pendulum again by the position of loose dial pointer.
- The difference of energy between E1and E2 is the energy absorbed by the specimen.

Hardness Test

The indentation is done in Rockwell hardness tester for determining the hardness of the quenched materials. The "C scale" is taken to find hardness. Rockwell Hardness is probably the most used hardness testing method because it is simple and self-contained. The 120^0 diamond cone was used an indenter. The load of 150 Kg is applied for the penetration. The hardness is measure at 3 or 4 different location of the each test sample and then average value are taken. The hardness values of the heat - treated specimens are generally higher than that of unheat-treated steel. In this case, the ability of the material to resist plastic deformation under indentation was used to evaluate hardness. The highest value of hardness is obtained on water quenched steel in comparison of oil & air.

Determination of Mechanical Properties

Mechanical properties of the heat treated and untreated samples are determined using standard method. Hardness of each samples are determined by using Rockwell Hardness testing machine and toughness of each samples are determined by using charpy test.

RESULTS AND DISCUSSIONS

The experimental results show that dual phase steels have excellent mechanical properties in terms of hardness and toughness.

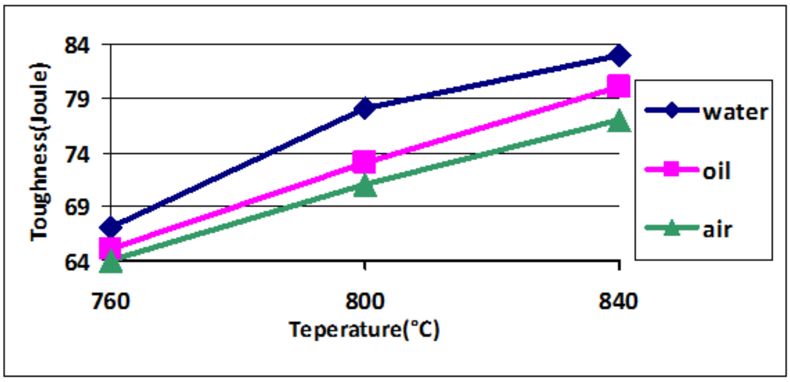
Table 3: Mechanical Properties of Untreated Steel

Specimen Temp.	Holding Time(min.)	Toughness(J)	Hardness(HRC)
0	0	61	18

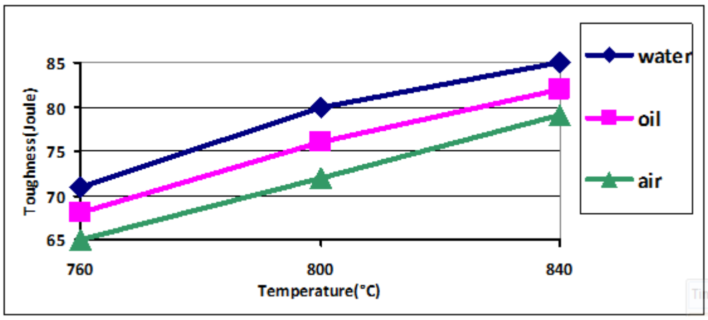
Table 4: Mechanical Properties of Treated Steel at Different Temperature, Holding Time & Quenched Medium

	Temperature	760			800			840		
	Holding Time	2	4	6	2	4	6	2	4	6
Toughness (J)	Water Quenched	67	71	73	78	80	82	83	85	86
	Oil Quenched	65	68	70	73	76	78	80	82	84
	Air quenched	64	65	67	71	72	74	77	79	81
Hardness (HRC)	Water Quenched	21	23	24	27	28	30	31	32	34
	Oil Quenched	20	22	23	26	27	29	30	31	32
	Air quenched	19	21	22	24	25	27	28	29	30

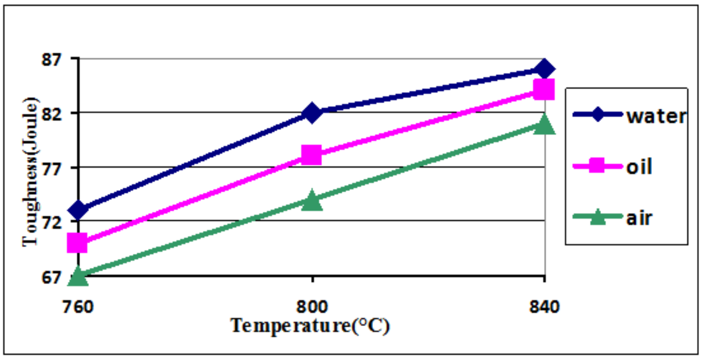
Temperature Vs Toughness



Graph 1: DP Steel Sample of Holding Time 2 Minutes Quenched in Different Mediums

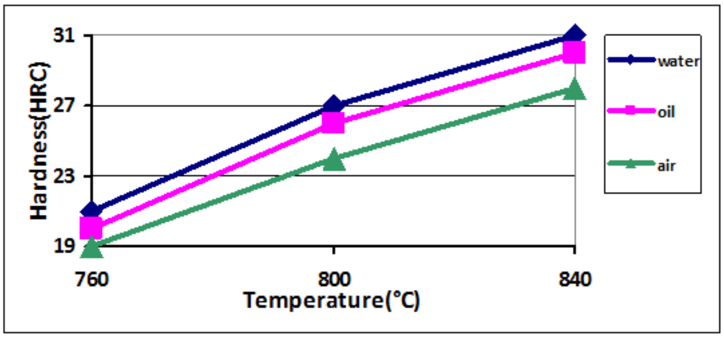


Graph 2: DP Steel Sample of Holding Time 4 Minutes Quenched in Different Mediums.

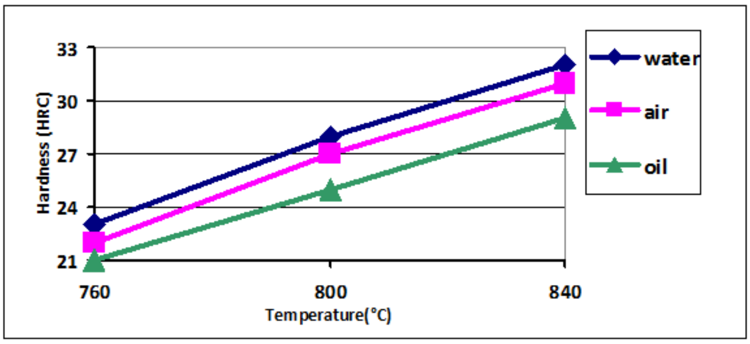


Graph 3: DP Steel Sample of Holding Time 6 Minutes Quenched in Different Mediums

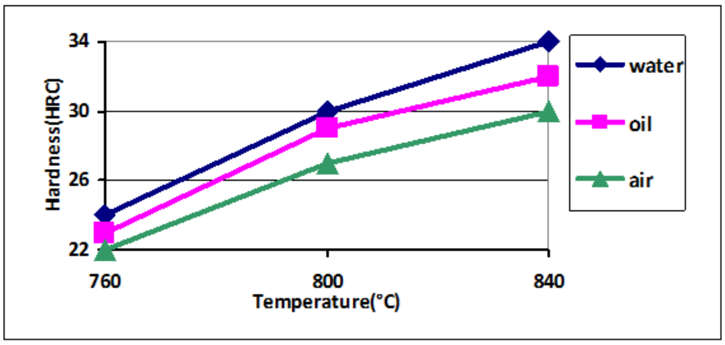
Temperature Vs Hardness



Graph 4: DP Steel Sample of Holding Time 2 Minutes Quenched in Different Mediums



Graph 5: DP Steel Sample of Holding Time 4 Minutes Quenched in Different Mediums



Graph 6: DP Steel Sample of Holding Time 6 Minutes Quenched in Different Mediums

CONCLUSIONS

- It has been established that palm oil can also be used as a quenching medium for steel since the mechanical strength of some of the samples quenched with palm oil improved when compared with those of the as-received sample.
- The water quenched material has the best mechanical properties (hardness and toughness) when compared to Oil & Air quenched medium. It is due to the formation of martensite structure after quenching.
- It also shows that holding time has an important role to play in the improvement of mechanical properties of steel. Large the holding time for higher temperature better the hardness and toughness of the steel samples

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